UNIVERSITY OF Southampton
School of Civil Engineering and the Environment

Tyndall Centre for Climate Change Research

Sea-Level Impacts of Climate Change

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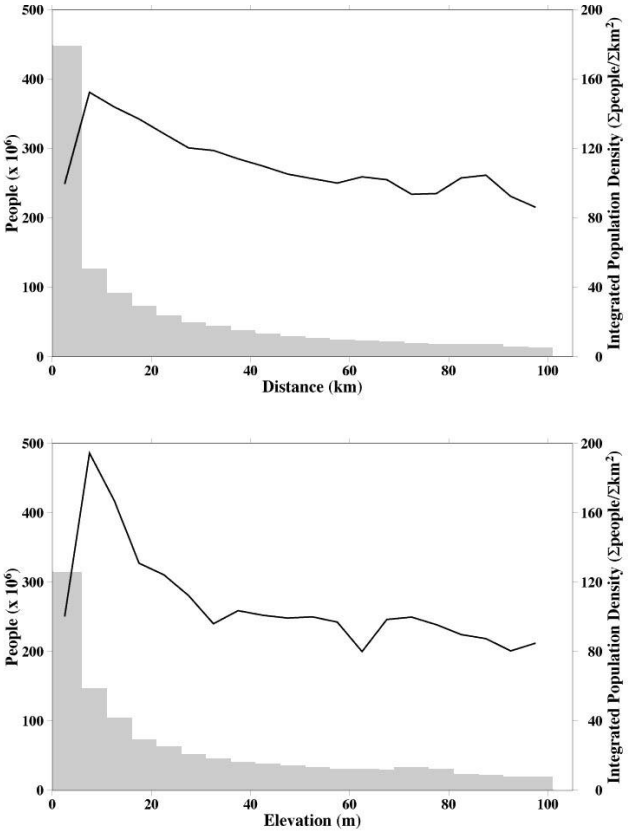
Improving the Assessment and Valuation of Climate Change Impacts for Policy and Regulatory Analysis:
Research on Climate Change Impacts and Associated Economic Damages
January 27-28 2011, Washington, DC

Plan

- Introduction
- What is sea-level rise?
- Impacts of sea-level rise
- Responses to sea-level rise
- Concluding thoughts

Coasts and People

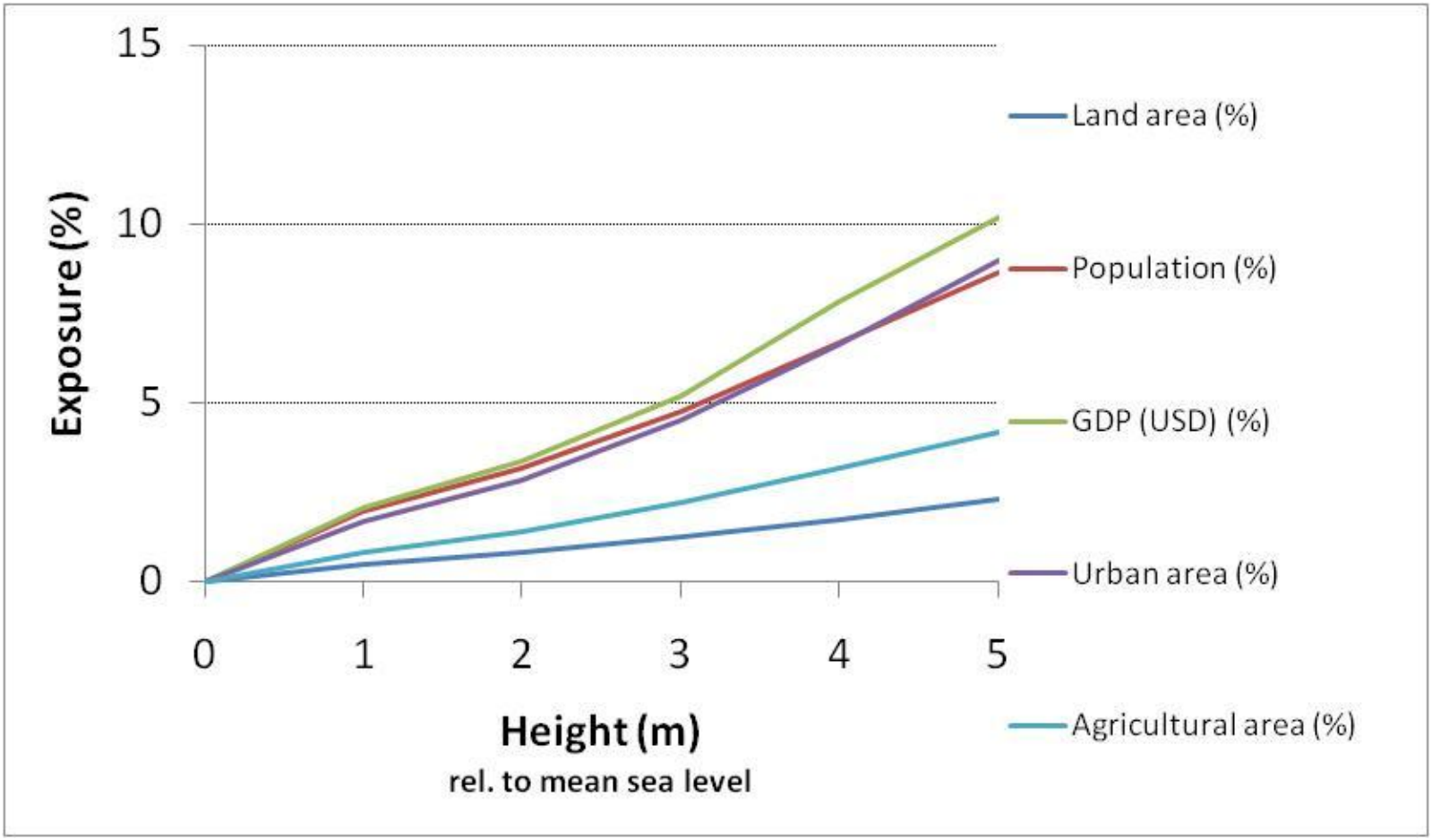
Population and economic density in the coastal zone is greater than other areas of the earth's surface.



Source: Nicholls and Small, 1993, Journal of Coastal Research

Current Exposure by Elevation

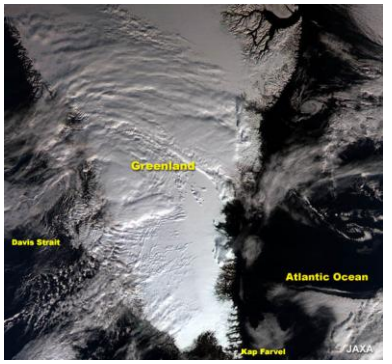
based on today's conditions in 84 developing countries



Source: Dagsputa et al (2007) World Bank Report (2009) Climatic Change

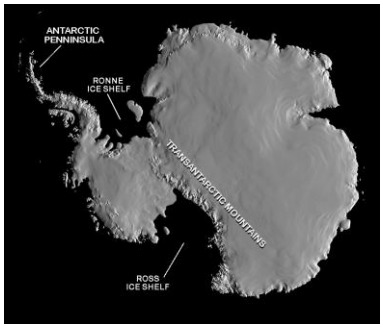
What is Sea-Level Rise?

Climate-induced Sea-Level Rise



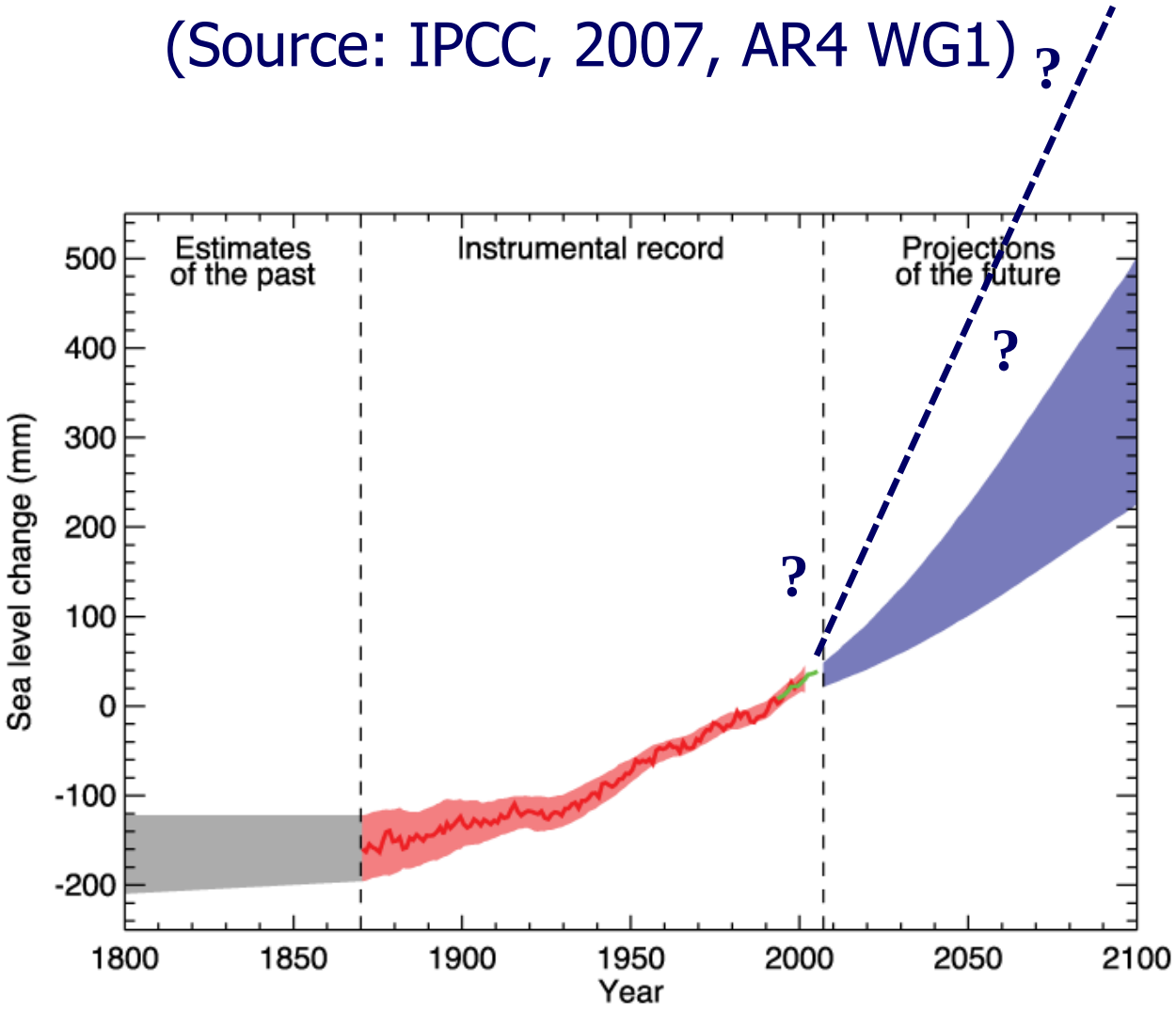
Rising temperatures lead to:

- Thermal expansion of seawater;
- Melting of land-based ice
  - Small glaciers (e.g., Rockies, Alaska)
  - Greenland ice sheet
  - West Antarctic ice sheet



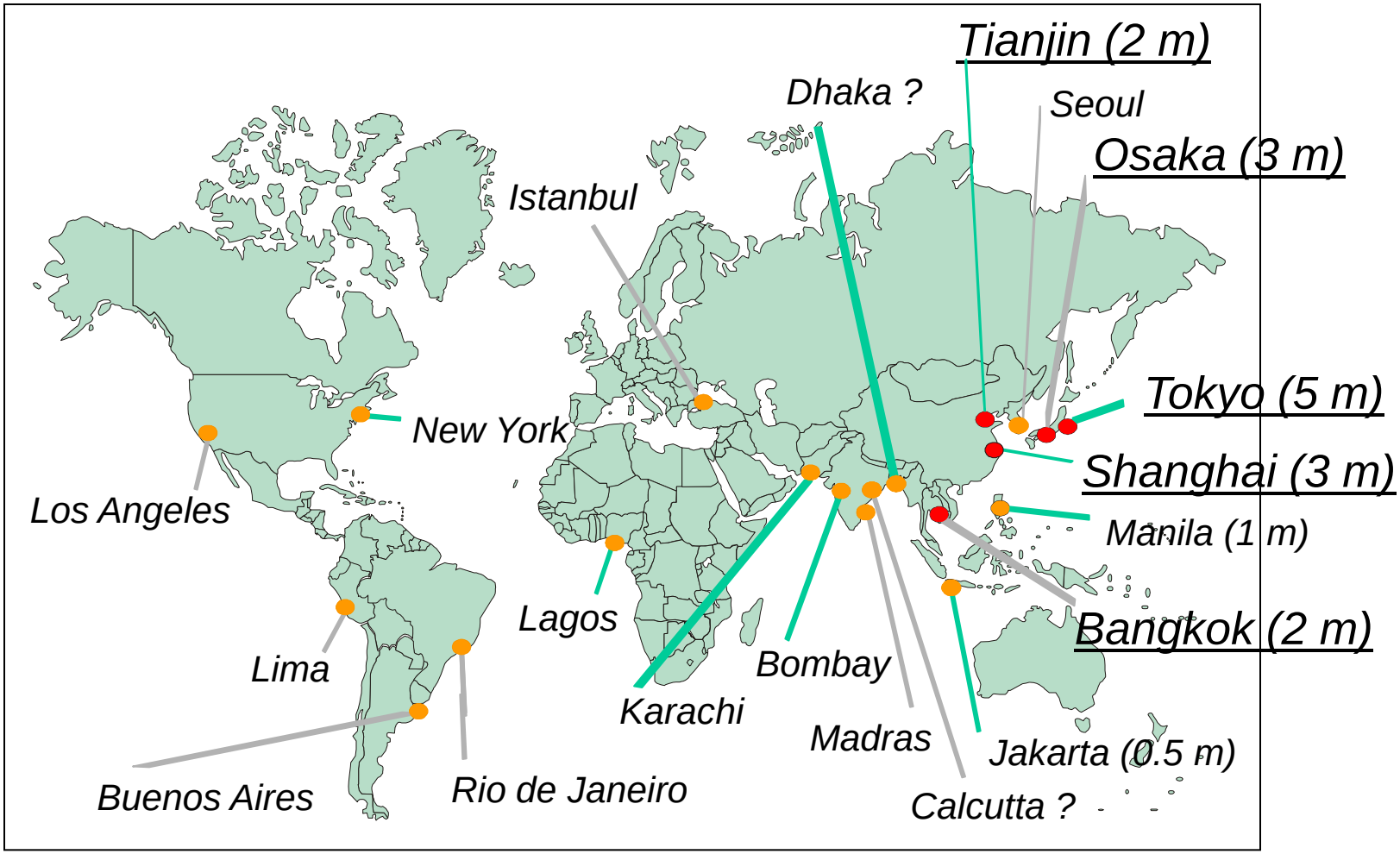
Global Sea-Level Rise

(Source: IPCC, 2007, AR4 WG1)



Subsiding Coastal Megacities

(maximum subsidence during the 20th Century)



Source: Nicholls (1995) GeoJournal

What Are The Impacts of Sea-Level Rise?

Physical Impacts of Sea-Level Rise

NATURAL SYSTEM EFFECT		INTERACTING FACTORS	
		CLIMATE	NON-CLIMATE
1. Inundation, flood and storm damage	a. Surge (flooding from the sea)	Wave/storm climate, Erosion, Sediment supply.	Sediment supply, Flood management, Erosion, Land reclamation
	b. Backwater effect (flooding from rivers)	Run-off.	Catchment management and land use.
2. Wetland loss (and change)		CO_2 fertilisation of biomass production, Sediment supply, Migration space	Sediment supply, Migration space, Land reclamation (i.e., direct destruction).
3. Erosion (of 'soft' morphology)		Sediment supply, Wave/storm climate.	Sediment supply.
4. Saltwater Intrusion	a. Surface Waters	Run-off.	Catchment management (over-extraction), Land use.
	b. Ground-water	Rainfall.	Land use, Aquifer use (over-pumping).
5. Higher water tables/ impeded drainage		Rainfall, Run-off.	Land use, Aquifer use, Catchment management.

Source: Nicholls (2010) Book on "Understanding Sea-Level Rise and Variability"

Socio-Economic Impacts of SLR

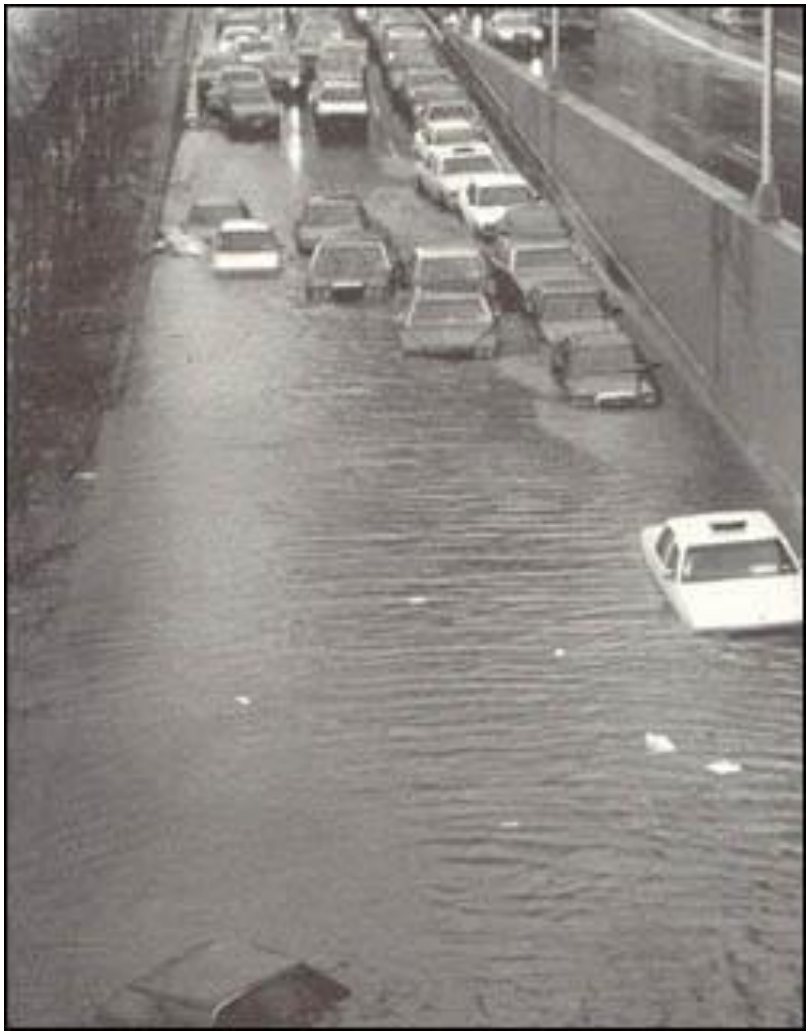
Coastal Socio-economic Sector	Sea-level rise physical impact				
	Inundation, etc.	Wetland loss	Erosion	Saltwater intrusion	Higher water tables/ etc.
Freshwater Resources	X	x	-	X	X
Agriculture and forestry	X	x	-	X	X
Fisheries and Aquaculture	X	X	x	X	-
Health	X	X	-	X	x
Recreation and tourism	X	X	X	-	-
Biodiversity	X	X	X	X	X
Settlements/ infrastructure	X	-	X	X	X

X = strong; x= weak; - = negligible or not established.

Source: Nicholls (2010) Book on "Understanding Sea-Level Rise and Variability"

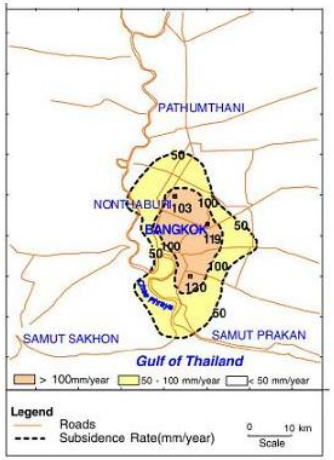
Floods: December Northeaster 1992

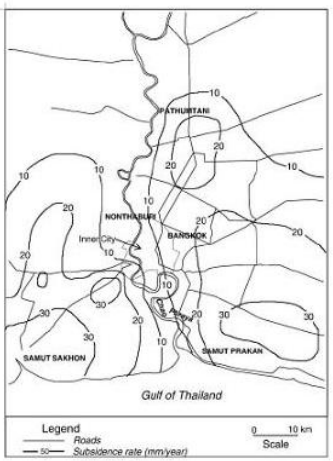
New York City – FDR Drive



Submergence Due to Subsidence

Bangkok Area



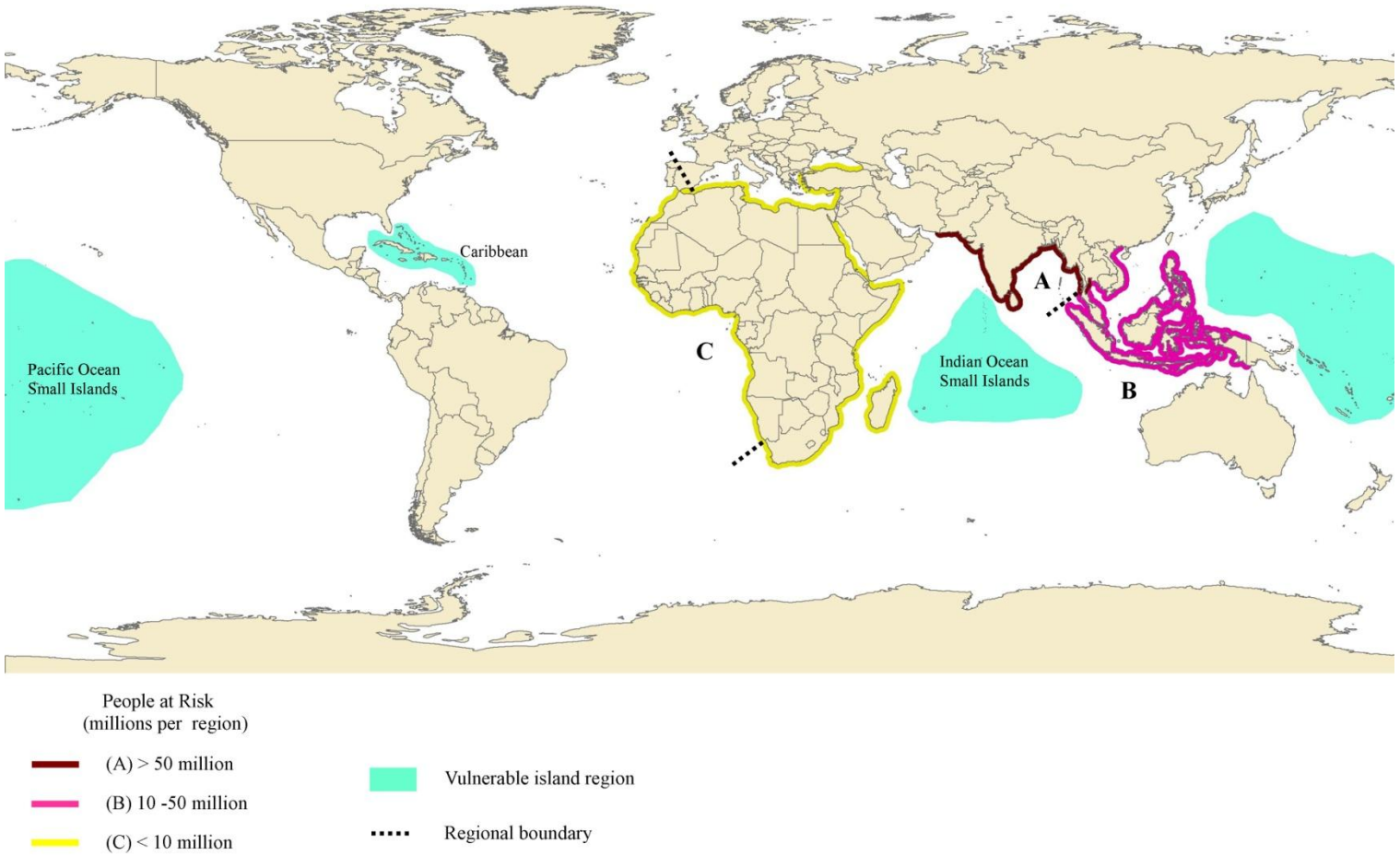


(a) 1981 (b) 2002

Source: Phien-Wej et al (2006) Engineering Geology

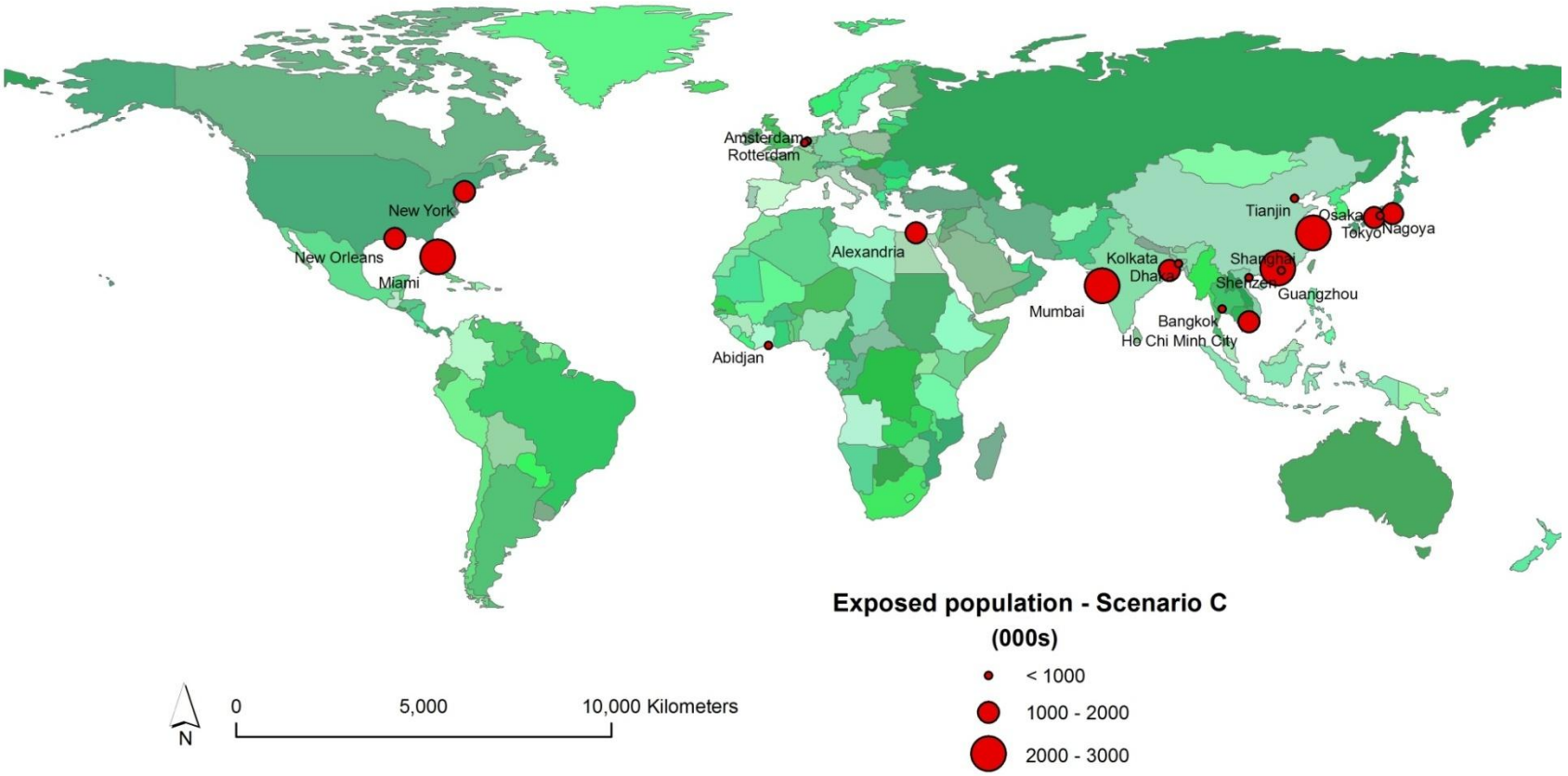
Threatened Coastal Areas

to 40-cm of SLR by the 2080s



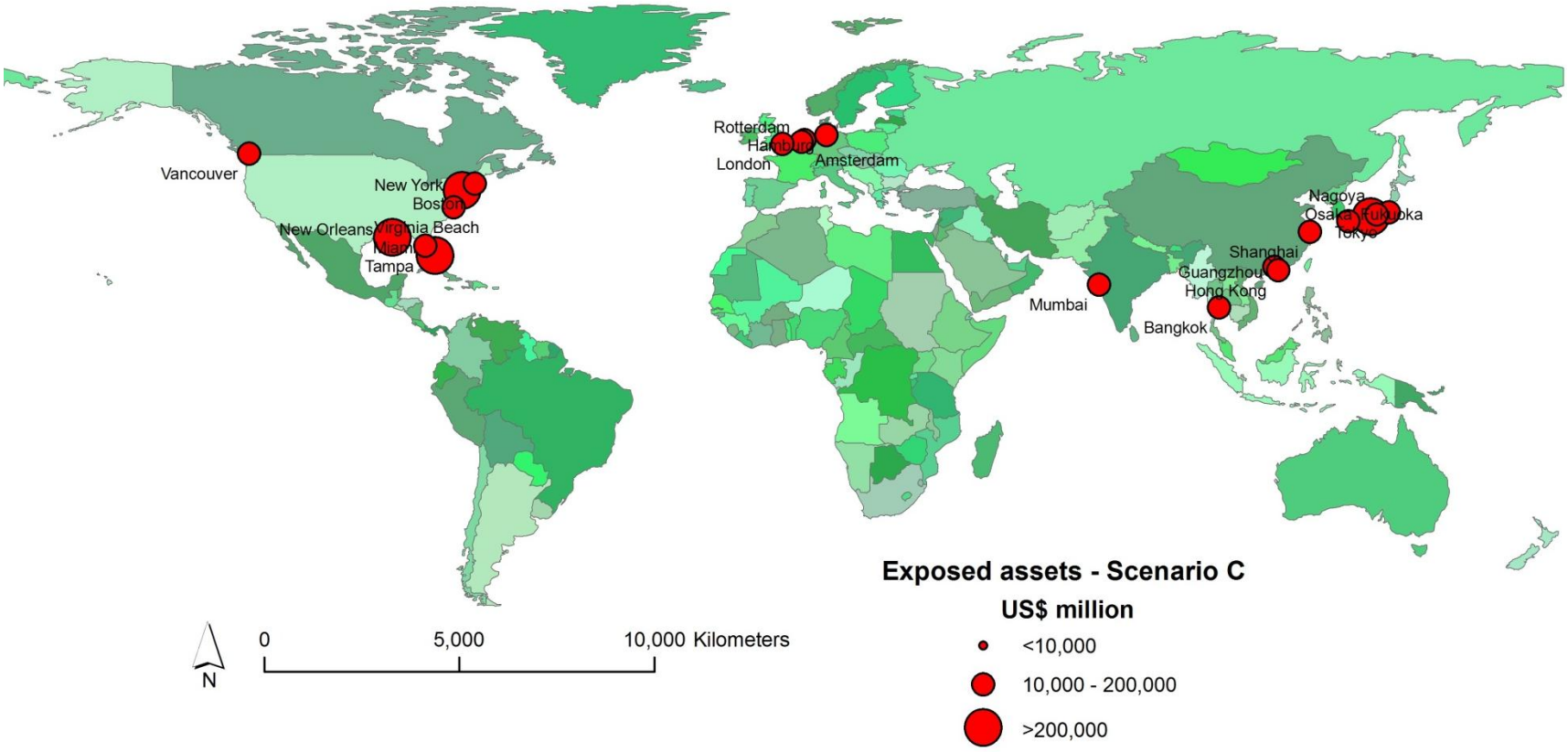
Source: Nicholls et al. (1999); see also Nicholls (2004) Global Environmental Change

Exposed Population 2005
Top 20 Cities – based on 100 year flood plain



Source: Nicholls et al., 2008, OECD Report

Exposed Assets 2005
Top 20 Cities – based on 100 year flood plain



Source: Nicholls et al., 2008, OECD Report

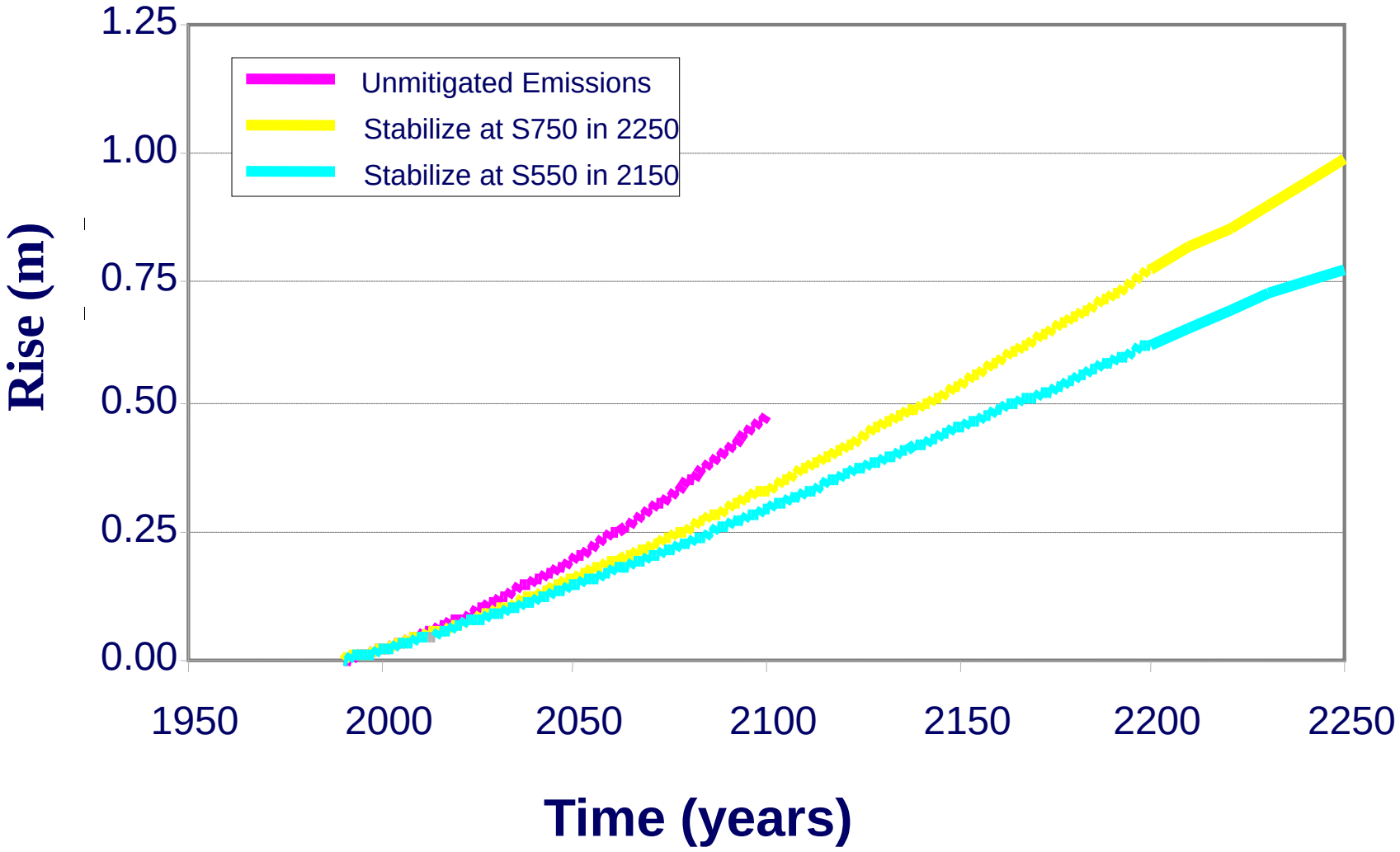
What Can We Do About Sea-Level Rise?

Mitigation – source control

Adaptation – change behaviour

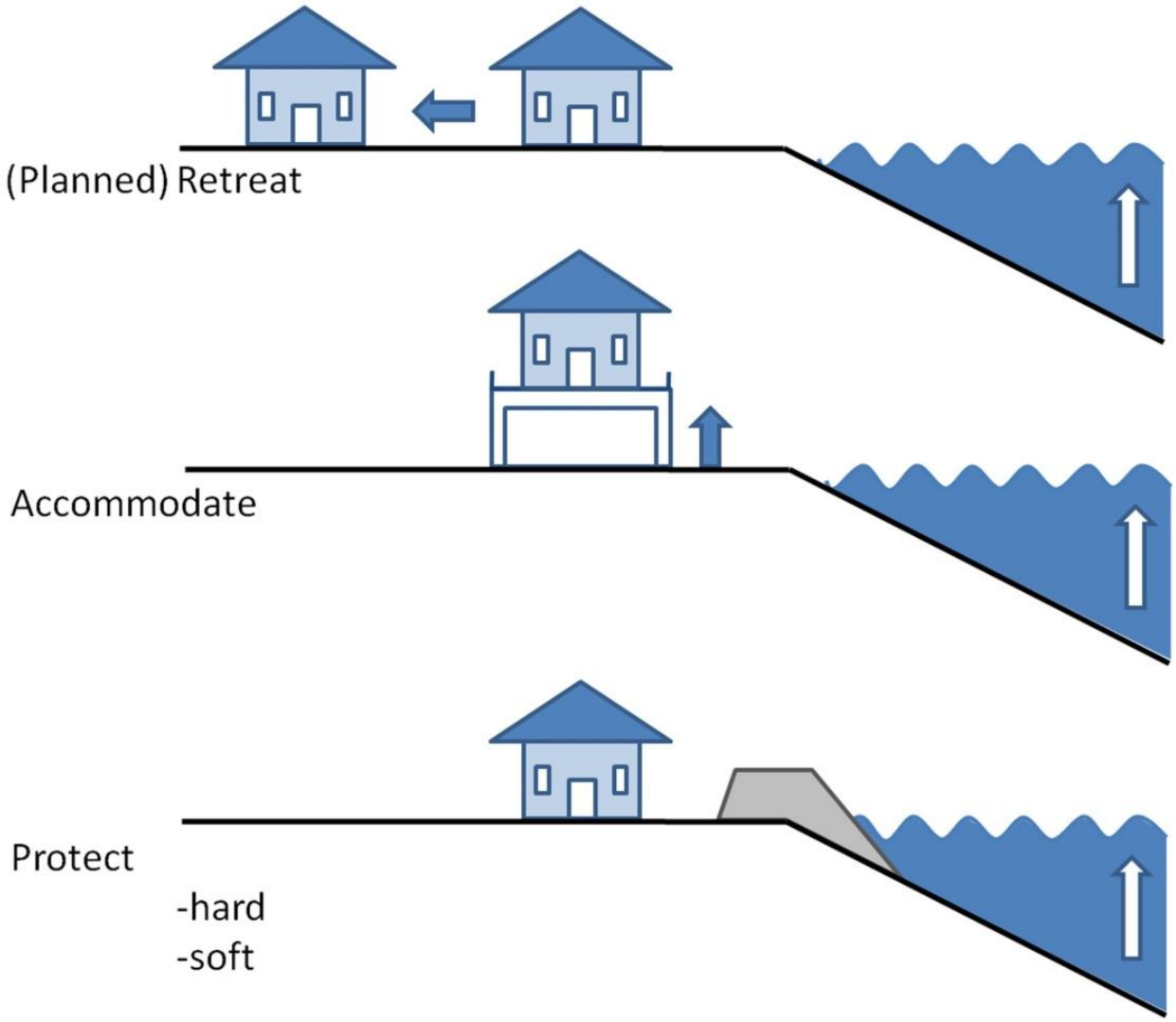
Mitigation Scenarios

Hadley Coupled Ocean-Atmosphere Model 2



Source: Nicholls and Lowe (2004) Global Environmental Change

Planned Adaptation to SLR



Source: Nicholls (2010) Book on "Understanding Sea-Level Rise and Variability"

Many Adaptation Options are Available

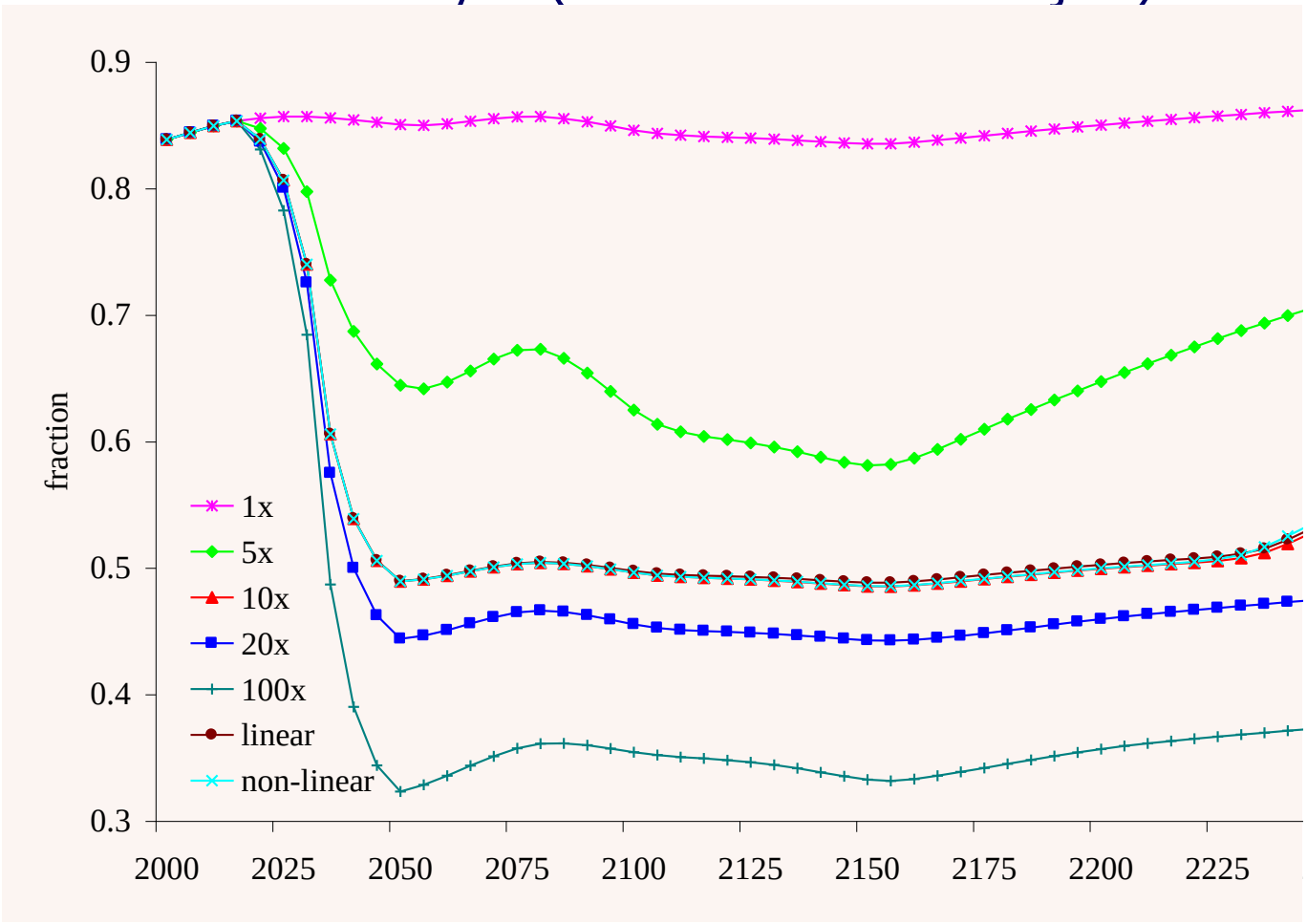
P – Protection; A – Accommodation; R – Retreat.

NATURAL SYSTEM EFFECT		POSSIBLE ADAPTATION RESPONSES
1. Inundation, flood and storm damage	a. Surge	Dikes/surge barriers [P], Building codes/floodwise buildings [A], Land use planning/hazard delineation [A/R].
	b. Backwater effect	
2. Wetland loss (and change)		Land use planning [A/R], Managed realignment/ forbid hard defences [R], Nourishment/sediment management [P].
3. Erosion (of 'soft' morphology)		Coast defences [P], Nourishment [P], Building setbacks [R].
4. Saltwater Intrusion	a. Surface Waters	Saltwater intrusion barriers [P], Change water abstraction [A/R].
	b. Ground-water	Freshwater injection [P], Change water abstraction [A/R].
5. Rising water tables/ impeded drainage		Upgrade drainage systems [P], Polders [P], Change land use [A], Land use planning/hazard delineation [A/R].

Source: Nicholls (2010) Book on "Understanding Sea-Level Rise and Variability"

Fraction of Coast Protected
Sensitivity Analysis on Protection Costs

FUND analysis (for the ATLANTIS Project)



Source: Nicholls et al (2008) Climatic Change

Optimists vs. Pessimists

Optimists	Pessimists
Possible small rise in sea level (< 0.5 m by 2100)	Possible large rise in sea level (> 1 m by 2100)
High benefit-cost ratios	Extreme events and disasters
Adaptation will work	Adaptation will fail or is unaffordable
Thriving subsiding megacities	Optimistic socio-economic scenarios
	Observed protection tends to be reactive rather than proactive – the adaptation deficit
	Disasters could trigger coastal abandonment, undermining the case for protection
	Retreat and accommodation have long lead times and need to start now

Concluding Remarks (1)

- Climate-induced sea-level rise is inevitable – the uncertainty is its magnitude.
- This will be compounded by subsidence in many densely-populated coastal areas.
- Risks are already rising, and this will continue.
- The worst-case (do nothing) impacts are dramatic.
- There are widely differing views concerning the success or failure of adaptation.

Concluding Remarks (2)

- Mitigation of climate and subsidence is needed to make the problem more manageable.
- To adapt to dynamic coastal risks, proactive assessment is required including:
  - defining the relevant drivers,
  - the potential impacts,
  - the potential adaptation responses,
  - selection of sustainable adaptation pathways.

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